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Americas Conference on Information Systems (AMCIS)

2008

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ABSTRACT

The DIADEM project aims to develop assistive web-based technologies, in the form of an Expert System (ES), to improve online services access for older adults faced with cognitive decline. Both during the initial analysis and during system trials it is necessary to observe users browsing and interacting with 'complex' online forms. However, establishing what constitutes a 'complex' online form for this target user group, proved to be somewhat of a challenge. Consequently we have developed a set of Bespoke Online Form Selection (BOFS) metrics, which have been used to inform the online form selection and categorising process. BOFS has proved to be a valuable tool to identify complex online forms for use in DIADEM's end-user trials. This paper presents the BOFS metrics, shows how these are aligned with the target user group, and demonstrates how BOFS has been of value within the context of the DIADEM project.

Keywords

Older adults, cognitive decline, form complexity, assistive technology, complexity.

INTRODUCTION

Older adults are currently one of the fastest growing groups of web-service users (Morrel & Mayhorn, 2000). Cognitive decline is considered to occur as a normal product of the ageing process (Peterson, et al. 1997), and is unavoidable in old age (Christensen, 2001). It is therefore not surprising that the number of individuals presenting cognitive decline within Europe is on the increase (DRC, 2005). A large proportion of these users are likely to require assistance, from both public and private agencies, to support independent living tasks such as grocery shopping, healthcare appointments, social service access, and bill paying. Government initiatives within the EU have led to the widespread adoption of the online services as a means to improve the efficiency and accessibility of government welfare services for their citizens. However, older adults are known to have less experience in the use of online services compared with younger adults (Morrel & Mayhorn, 2000), and coupled with increased levels of cognitive decline, older adults are at a distinct disadvantage when attempting to effectively access such services.

Consequently, there is a need to develop assistive technologies that enable older adults to access online services more effectively. There are a wide variety of services that such people might use ranging from online shopping and purchasing travel tickets to requesting welfare support and booking a hospital appointment. In every case the user needs to go through several web pages "filling in a form" to get the desired result. It is important to distinguish between what we, as developers, perceive to be a form and what users perceive. Technically each new HTML page is a separate form. However, a user, used to turning the pages of paper forms, is likely to perceive such a sequence a single, multi page form. In this paper we are concerned with user perceptions and references to a "form" should be read any sequence of pages that the user will perceive as soliciting the data associated with a single transaction.

The problem then is to find a basis for reviewing this range of possible form filling transactions and making an assessment of the relative complexity of the forms being used. In any bounded piece of usability research it will be necessary to consider whether the forms used in actual experimentation are typical of other online activities if the results are to be generalisable. As

indicated below the existing research has trended to use methods that are dependent on the responses of user panels and not transferable to desktop evaluation across a wide range of sites. The aim of this paper is to present the Bespoke Online Form Selection (BOFS) metrics that were developed to fill this need.

The remainder of this paper is structured as follows. In the next section the DIADEM project is described and existing website usability evaluation methods are reviewed to establish the need for a new online form complexity metric. T main section of the paper then presents the BOFS metrics. The last part of the paper reports on the effectiveness of the BOFS method within the context of the DIADEM project.

BACKGROUND

The DIADEM project, funded by the European Commission (EC), focuses on improving older adults' access to online forms via the development of DIADEM, an Expert Systems (ES) that monitors user browsing and input activity, and adapts and personalises the online form interface and behaviour to meet the individual user's needs. A series of user trials are being carried out in the UK, Italy and Norway, initially to collect functional and usability requirements for the development of DIADEM, and subsequently to evaluate the effectiveness of the DIADEM. A key aspect of the user trials is to observe older adults whilst they interact with, and complete, complex online forms. However, identifying and operationalising what constitutes a 'complex' online form specifically for older adults, as a user group, has proved to be somewhat of a challenge. There appears to be a gap in existing literature relating to the identification of such online forms. As a result, we set about developing a set of Bespoke Online Forms Selection (BOFS) metrics to assess online form complexity guided by the five cognitive domains that are known to deteriorate in cognitive decline. These can be detected by the Addenbrooke's cognitive examination (Mioshi et al. 2006).

Existing Research

Currently the most common approach to measuring complexity of web-content is carried out in the usability evaluation research domain. Usability evaluation methods consider three user based criteria; the effectiveness, the efficiency and the satisfaction with which the user can interact with web-content. Several studies have been carried out to assess these usability criteria. For example, efficiency is has been assessed by measuring the time it takes for a user to navigate from one hypertext node to the next (Cribbin & Chen, 2001), by measuring the user's heart rate variability whilst carrying out specific computer based tasks (Iszo & Lang, 2000), and by counting the number of mouse-clicks while carrying out browsing tasks (Drucker et al. 2002). Effectiveness is measured in Bayles (2002) by the ability of the user to recall of web-based banner advertisements, and in Dumais et al. (2002), by the number of web-based tasks the user failed to complete. McGrenere et al. (2002) measure satisfaction by asking users to report their perceived annoyance level, and Chevalier and Bonnardel (2007) measure it by the number and nature of constraints that are verbalised by users whilst interacting with web-content. These are just a few of a large number of studies that have been carried out within the usability evaluation domain (see Hornbaek 2006 for a more comprehensive review of 180 contemporary research articles in this area).

Despite much valuable research in this area, there seems to be a lack of literature that relates specifically to the DIADEM project's research needs: that is a set of metrics that can be used to pragmatically assess the likely level of complexity, for the older adult user group, of a given sample of online forms. Perhaps the reason for this is that the overwhelming majority of usability research is trial based, and takes place with the user present. Therefore, such research does not tend to develop tools or heuristics for objective, rapid and consistent assessment of online forms by inspection, as opposed to end-user report or performance. The set of BOFS metrics presented in the next section were developed as a direct response to the DIADEM project's need for an inspection based approach.

THE BOFS METRICS

At present there is little research into evaluating online forms for the elderly user group (discussed above), and as a consequence, formal methods for analysing online form complexity have yet to be addressed. Having reviewed related research domains, a bespoke content analysis method was developed that provides a structured and yet straightforward means of analysing the complexity of online forms for older adults. The Bespoke Online Form Selection (BOFS) method aims to evaluate a wide range of online forms producing quantitative results that give a relative estimate of an online form's 'level of complexity'.

BOFS is aimed at being a generic solution, assessing a range of online form criteria including; the total number of pages in the online form, the amount of scrolling required within a form, whether the online form gives an idea of the users location within the context of the whole form, and so forth. In addition to these global navigation elements Miller and Jarrett (2001) identify five data input mechanisms used within HTML 4.0 forms:

- drop-down boxes,
- radio buttons,
- check boxes,
- hyperlinks, and
- type-in boxes.

Since online forms are primarily concerned with users inputting data, BOFS also assesses online form complexity according to these five types of input mechanism, and thus can be applied to any online form that has been designed in standard HTML 4.0 format, regardless of the genre of the online form or indeed the specific subject content of the online form.

BOFS Complexity Assessment Criteria

Several criteria are used to assess online form complexity for older adults, each of which is discussed below. To demonstrate how these criteria are relevant to the assessment of online form complexity for the user group in question, we use the five sub-scales of the Addenbrooke's cognitive examination (ACE-R) (Mioshi et al. 2006). These represent the five cognitive domains that are known to be affected as a result of cognitive decline and they provide a justification for inclusion of the assessment criteria incorporated within the BOFS assessment method. ACE-R is a comprehensive cognitive-ability screening tool, which is now becoming widely used to identify users that are showing signs of cognitive decline. The five cognitive domains that decline in this user group, as indicated by the ACE-R examination, are as follows:

- *ACE-R1* - Attention and orientation: Users have impaired skills related to orientation within time and space, and maintaining attention for extended periods of time.
- *ACE-R2* - Memory: Impaired memory recall, in the short term and short to medium term.
- *ACE-R3* - Fluency: Impaired fluency of categorisation (for example categorising words), impaired inference, assimilation, interpretation, and elaboration of related concepts.
- *ACE-R4* - Language: Impaired ability to recall low frequency words and irregular words.
- *ACE-R5* - Visuospatial: Impaired visual intuition, and interpreting or implying meaning from visual cues.

In general age related decline also brings with it a loss of flexibility or lack of the ability to adapt to new scenarios or ways of working. These people loose the adaptability that would otherwise mitigate the impact of the factors above. The following is a description of each of the criteria used by the BOFS method. Each of them is also associated with one or more of the ACE-R cognitive decline domains listed above. The BOFS assessment criteria are as follows:

BOFS1. Total number of pages in the online form

A high number of pages included within an online form are likely to increase cognitive load, encourage fatigue, and require the user to maintain attention for prolonged periods of time (ACE-R1). Any visual cues used, for example, to demonstrate to the user the form structure such as a site map, will be more complex as the number of pages increase in the form increase, to reflect the locations of the various pages, which in turn could put increased strain on users interpreting these cues (ACE-R5). To establish the number of pages within an online form the total number of pages (screens) contained within the form was recorded. The total number of pages includes ALL pages including those that do not contain questions such as introductory or instruction pages and confirmation of submission pages.

BOFS2. Total number of pages that require scrolling to view entire page

It is important that the end-user understands 'where they are' within a page. If scrolling is required to complete the page, the end-user may become confused and disoriented (ACE-R1). By scrolling down, the end-user may also 'miss' questions and not complete the page at first attempt, it may also put strains on their ability to visually understand the significance and meaning of visual cues within the form (ACE-R5). Here the number of pages contained within the form that require the user to scroll down the page (screen) to be able to view and complete the questions was recorded.

BOFS3. Current location (page) indicator

When completing online forms, it is important for the end-user to 'know where they currently are' within the online form to reduce confusion, disorientation (ACE-R1), and to support question completion. This is also important to minimise the cognitive load placed on the user, in terms of having to recall from memory what steps they took to navigate to this location (ACE-R2), and infer, based on the general content and concept structure of the form what steps they need to take to return to their original location (ACE-R3). Therefore, if current location identifiers existed within the form this was recorded as zero (0). If current location identifiers did not exist within this was recorded as one (1) – more complex.

Examples of current location identifiers include:

```
Instructions>Personal Details>Income;
```
or `Page 3; Step 3`

BOFS4. Overall location (form) indicator

When completing online forms, it is important for the user to know their overall location within the form, to reduce confusion, disorientation (ACE-R1). It also aids the user in knowing how much of the form they have already completed, hence reducing cognitive load in terms of having to recall from memory where they are within the context of the online form (ACE-R2), how much they have completed, and how much they think they still have to complete. If overall location identifiers existed within the form this was recorded as zero (0). If overall location identifiers did not exist within the form this was recorded as one (1).

Examples of overall location identifiers include:

```
Page 1 of 10;
```
or `Stage 1 of 10;`

or 

BOFS5. Number of questions (including sub-questions) in form

A high number of questions are likely to lead to greater cognitive demands being placed on the end-user, and may induce end-user frustration and fatigue (ACE-R1). The amount of text included in the online form is likely to increase as the number of questions increases, and thus may pose more of a challenge to the user in terms of required memory recall functions in order to answer questions (ACE-R2). It is also likely to require the user to put more effort into assimilation of information, interpreting the meaning of the questions (ACE-R3), and recalling low frequency and irregular words as they occur within the online form content (ACE-R4). The number of visual cues used within the online form is also likely to increase as the number of questions increase, and therefore could put increased demand on visual intuition from the user ACE-R5). Therefore, the total number of questions, including sub-questions (e.g. 2, 2a, 2b, etc) was recorded.

BOFS6. Maximum number of possible responses

Questions posed within a form may have a number of possible pre-determined responses (typically generated based on form processing requirements). The larger the number of possible responses to questions presented within a form, again the greater the likelihood of inducing greater cognitive demands in terms of memory (ACE-R2), and assimilation and elaboration of the conceptual structure of the possible answers to those questions (ACE-R3). In 'simple' forms, there will typically be one response per question. However, where the user was requested to choose multiple responses, the number of multiple responses was also added to the total count. Self-populating responses were not counted as a 'response'. Only those responses entered or selected directly by the end-user were counted in this instance as they would likely incur minimal cognitive effort.

BOFS7. Number of responses requiring additional information

A form is likely to be perceived as more time consuming to complete from an end user perspective, when information from other sources is required to be able to complete the form, thus putting strain on the user's attention span (ACE-R1)., and also on their memory, should the user first need to recall where they have stored the required documents (ACE-R2). Therefore the number of questions that require an end-user to retrieve information from elsewhere, such as a paper document, an electronic file, a driving licence etc. to be able to complete the response, was recorded. Here it was assumed (do to the durability of long term memory) that questions, such as name and date of birth, etc. would not require the retrieval of information from elsewhere.

BOFS8. Input Mechanisms

According to Miller and Jarrett (2001), HTML based online forms have the functionality of enabling end-users to input answers to questions in five forms: drop-down boxes, radio buttons, check boxes, hyperlinks, and type-in boxes. Based on these five forms of input, BOFS derives the following criteria that can be additionally used to evaluate the variety of input styles that add to the complexity of an online form.

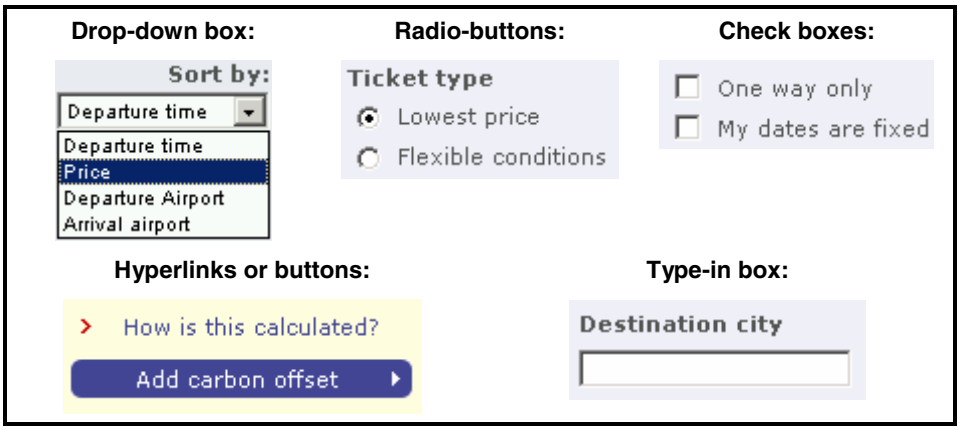

Figure 1: Examples of the five input elements[1]

BOFS8a. Drop-Down Boxes

In analysing the use of drop-down boxes within a form, the following measures were employed:

- Total number of drop down boxes in the online form.
- Total number of drop-down boxes that require scrolling in the online form.
- Total number of drop-down boxes grouped by number of options.

The number of drop-down boxes presented within each form was recorded. In addition, the number of drop-down boxes that did not present all options on the screen at the same time and required scrolling were also recorded. Where scrolling is required, there is an expectation that the end-user will be able to 'find', by requiring increased levels of inference and interpretation of the options they wish to select (ACE-R3). However, if all the options are not presented at the same time, an extra demand is made on short term memory (ACE-R2) in that the end-user will have to 'recall' the options and the associated interpretations/eliminations in relation to each option. Thus, scrolling through a drop-down box, when all of the options are not visible on the screen is likely to incur greater cognitive demands.

The number of drop down boxes containing a specific number of options was also recorded to identify forms that used not only a high number of drop-down boxes but also a high number of options. Selecting a response from a long list of options, all of which require some cognitive effort is likely to incur greater cognitive load than from a short list of options (ACE-R3). This was documented as follows, e.g. a form containing a total of 7 drop down boxes with 4 comprising 3 options and 3 comprising 7 options would be recorded as:

Number of options	1	2	3	4	5	6	7	8	9	…
Number of drop down boxes			**4**				**3**			

Figure 2: Recording template for selection items

[1] http://www.britishairways.com/travel/ as rendered by Microsoft Internet Explorer 6.0

BOFS8b. Radio Buttons

In analysing the use of radio buttons within a form, the following measures were employed:

- Number of radio buttons in form
- Number of radio buttons grouped by number of options

The total number of questions requiring radio button input was recorded. If a 'type-in' box was presented to capture end-user information (e.g. other… or if the end user has to justify their selection) this type-in box was included within the total count of 'type-in' boxes as documented below. The number of radio buttons containing a specific number of options was also recorded because, as above, selecting a response from a long list of options is likely to incur a proportionately greater cognitive load in terms of interpreting and understanding (ACE-R3) and having to hold all possible options in memory (ACE-R2).

BOFS8c. Check boxes

In analysing the use of check boxes within a form, the following measures were employed:

- Number of check boxes in form
- Number of check boxes grouped by number of options

The total number of questions in each form requiring check box input was recorded. As before if a 'type-in' box was presented to capture 'other' end-user information it was included within the total count of 'type-in' boxes as documented below. Once again the number of check boxes containing a specific number of options was also recorded (as above) to identify forms likely to incur greater cognitive load (ACE-R2 and ACE-R3),

BOFS8d. Hyperlinks or Buttons

In analysing the use of hyperlinks or buttons within a form, the following measures were employed:

- Number of hyperlinks or buttons in form
- Number of hyperlinks or buttons grouped by number of options

Whether presented as a hyper link (a click sensitive text) or as a button (a click sensitive image) these elements trigger display changes or actions that record information. The total number of questions or actions requiring a response by clicking hyperlinks or buttons presented within the entire form was recorded. Also the number of hyperlinks or buttons representing a specific number of options was also recorded to identify forms that used not only a high number of hyperlinks or buttons but also a high number of options. Where the buttons or links required selecting a response from a list of options the pattern was recorded as above (ACE-R2 and ACE-R3). Hyperlinks also have the potential of disorientating the user is it takes them to a different section of the form (ACE-R1).

BOFS8e. Type-in box

In analysing the use of type-in boxes within a form, the following measures were employed:

- Number of type in boxes.
- Number of type in boxes indicating that more than one sentence or statement required

Here the total number of type-in boxes presented throughout the form was recorded. In addition the number of type-in boxes that would typically require more than one sentence (e.g. indicated within the form by a large text box space or by a request to provide a justification) was also recorded. Users required to complete type-in box answers may be required to maintain attention for comparatively long periods of time (ACE-R1), compared with for example check box answers, they may also be required to recall information from memory if they are required to provide an elaborate, free-style answers (ACE-R2).

HTML 5, Web Forms 2.0 and other Online Technologies

Miller and Jarrett (2001) add a critical caveat to this selection of five types of forms element or data entry behaviour; namely "*it is possible to create much more sophisticated forms with the use of other technologies such as Java applets or image maps embedded in your web page*". This statement was made in 2001 and the increasing use of ActiveX components downloaded to Microsoft's Internet Explorer must be added to the catalogue of "other" technologies. If the BOFS is to be comprehensive it cannot simply ignore the implications of this statement.

Pragmatically there is nothing a project like DIADEM can achieve where an application provider opts out of the standards and interoperability framework to deliver their own proprietary solutions. However, there is a need to consider whether these opt outs are forced because the categories identified above fail to cover something users will perceive as significant form navigation or data entry behaviour.

When it was developed the W3C standards body considered the <FORM> and input control elements in HTML 4.0 (W3C, 1999), combined with hyperlinks, to be adequate for the needs of online transactions and forms of all common types. However, W3C has reviewed the operation of the standard and the working draft of Web Forms 2.0 (W3C, 2006) defines the proposed extensions to the <FORM> element in HTML 5. Most of the recommended changes are richer behaviour or different renderings of the operations described above that don't change the user perception of form complexity upon which BOFS is based.

Web Forms 2.0 does recommend the addition of a range control that can look like a slider or volume control and a variation on a numeric type-in box by adding count-up and count-down buttons. These are illustrated in Figure 3. In terms of evaluating and comparing existing forms the five input behaviours and criteria above appear to be adequate for a wide range of services and applications. However, in the medium to long-term additional criteria within BOFS8 will be needed to deal with Slider and Spinner controls.

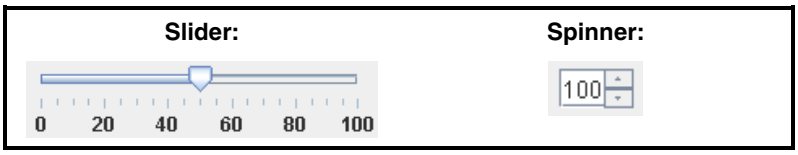

Figure 3: Additional input elements in HTML 5

UTILISING BOFS METRICS IN DIADEM

The following procedure, utilising the BOFS metrics outlined in 0, was followed during the course of the DIADEM project to assess the complexity of 24 online forms. The forms were initially ranked as a function of the total number of questions counted in each respective online form (BOFS5 in section 0). This was considered the most influential assessment metric, since it is the only metric that is seen to impact on all five of the cognitive domains tested in the ACE-R. There was a tendency for the other metrics (1-4, 6 and 7) to also increase as the question count rises making it unnecessary to aggregate the figures to get a first pass ranking of the forms.

In selecting the final set to be used in interviews with elderly users at the systems analysis stage the DIADEM team looked for the more complex forms that also contained a wide variety input mechanisms (drop-down boxes, radio buttons, check boxes, hyperlinks and type-in boxes). Preference was given to:

- A high number of pages, particularly if they required scrolling (BOFS1 and 2).
- Failure to provide a cue of 'where they currently are' (BOFS3 and 4).
- A high number of possible responses (BOFS 6).
- A high number of questions requiring look-up information (BOFS 7).
- A high number of type-in boxes that require more than one sentence (BOFS8e).

The project has also needed to consider whether forms to be used in experimental trials of the DIADEM software are sufficiently representative of the data input challenges faced by the target user group. The BOFS was used again at this stage to evaluate the coverage and complexity of the selected forms.

Effectiveness of BOFS

The BOFS metrics have been successfully used within the context of the DIADEM project. The experience has identified several benefits associated with such metrics:

- Having a set of metrics that can be used to measure complexity directly from the online form, as opposed to, for example, running a separate set of trials to establish complexity, has saved significant time and resources.
- BOFS metrics have provided a standardised measure of online form complexity, which has proved to be applicable to a wide range of online forms regardless of subject content or language. This has been a great benefit with the need to compare forms used in three different European countries and languages. As a result, to the project has been able to ensure consistency across partner countries, in terms of the types and complexity of online forms used within the respective tasks.
- BOFS has provided tangible and comparable metrics of online form complexity, which has meant that the risks of potential ambiguity and subjectivity when assessing online form complexity has been managed and considerably reduced.
- Since all metrics are recorded, BOFS has had the added benefit of providing the dimension of traceability of selection results, that otherwise may not have been available via other assessment methods.

CONCLUDING REMARKS

In this paper, a need has been identified, for the development of metrics that serve as an effective means of assessment of online form complexity for the older adult user group. As a result, the BOFS metrics have been developed and presented. To demonstrate how the BOFS metrics can be used within a real world context, the procedure employed to assess online form complexity on the DIADEM project was then presented. Finally, the effectiveness of BOFS as a set of assessment metrics has been discussed.

The BOFS metrics have proved particularly useful for measuring online form complexity specific to the older adult user group. This is something that does not appear to have been done as yet in existing research, and thus has proved extremely valuable in meeting the needs of the DIADEM project. They have proved to be an effective tool that is relatively independent of form genre, content and language. The generic nature of BOFS means that it is a versatile tool that could be used in a wide range of contexts.

The DIADEM project will not reach its conclusion until August 2009. The BOFS metrics will continue to be used, and if necessary refined, as we develop the capabilities of our system to respond to user's needs and help them through the form filling process. In the final trials scheduled for second quarter 2009 the system will be applied to a wider range of transaction types. This will deliberately test the assumptions that DIADEM (and BOFS) can be applied in a variety of different social and commercial transaction types from both the eCommerce and eGovernment scenarios.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the European Union funding of DIADEM as a Framework 6 project (contract 034106). They also wish to acknowledge the contributions of the other DIADEM consortium members - Norsk Regnesentral (Norway), Bluegarden AS (Norway), MORE AS (Norway), CSI-Piemonte (Italy), Sheffield City Council (UK), and Citta di Torino (Italy) - in supporting this research.

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